US008240051B2

(12) **United States Patent**
Fedock et al.

(10) **Patent No.: US 8,240,051 B2**
(45) **Date of Patent: Aug. 14, 2012**

(54) **METHOD FOR ERECTION OF A SOLAR RECEIVER AND SUPPORT TOWER**

(75) Inventors: **Dennis S. Fedock**, Marshallville, OH (US); **Joe C. Roudebush**, Uniontown, OH (US); **Thomas J. Studer**, Canal Fulton, OH (US)

(73) Assignee: **Babcock & Wilcox Power Generation Group, Inc.**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 379 days.

(21) Appl. No.: **12/435,062**

(22) Filed: **May 4, 2009**

(65) **Prior Publication Data**

US 2009/0276993 A1 Nov. 12, 2009

Related U.S. Application Data

(60) Provisional application No. 61/051,171, filed on May 7, 2008.

(51) **Int. Cl.**
E04H 12/34 (2006.01)
E04H 12/10 (2006.01)

(52) **U.S. Cl.** **29/890.033**; 29/429; 29/897.31; 52/651.05; 52/745.18

(58) **Field of Classification Search** ..... 29/429, 29/897.3, 897.31, 897.312, 469, 890.033; 52/745.17, 745.18, 651.01–651.09; 254/93 R, 254/126, 93 L
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,211,427	A	*	10/1965	Bristow, Jr.	254/89 H
3,213,575	A	*	10/1965	Boczek	52/123.1
3,894,635	A	*	7/1975	Reich	212/176
3,924,604	A	*	12/1975	Anderson	126/606
4,013,885	A	*	3/1977	Blitz	250/203.4
4,028,792	A	*	6/1977	Tax et al.	29/431
4,125,193	A	*	11/1978	Matsumoto	212/203
4,196,814	A	*	4/1980	Reich	212/204
4,274,542	A	*	6/1981	Barclay	212/270
5,263,835	A	*	11/1993	Schmidt	425/64
5,983,634	A	*	11/1999	Drucker	60/398
6,868,646	B1	*	3/2005	Perina	52/745.17
7,115,851	B2	*	10/2006	Zhang	250/203.4
7,690,377	B2	*	4/2010	Goldman et al.	126/655
2003/0213765	A1	*	11/2003	St-Germain	212/294
2010/0044330	A1	*	2/2010	Vorhies et al.	212/175
2010/0170188	A1	*	7/2010	Zilmer et al.	52/745.17

FOREIGN PATENT DOCUMENTS

JP	03021777	A	*	1/1991
JP	08311818	A	*	11/1996
JP	2006077456	A	*	3/2006
SU	831714	B	*	5/1981
SU	1126530	A	*	11/1984

OTHER PUBLICATIONS

Farret, Felix A.; Simões, M. Godoy (2006). Integration of Alternative Sources of Energy.. John Wiley & Sons. Online version available at: http://www.knovel.com/web/portal/browse/display?_EXT_KNOVEL_DISPLAY_bookid=2443&VerticalID=0.*

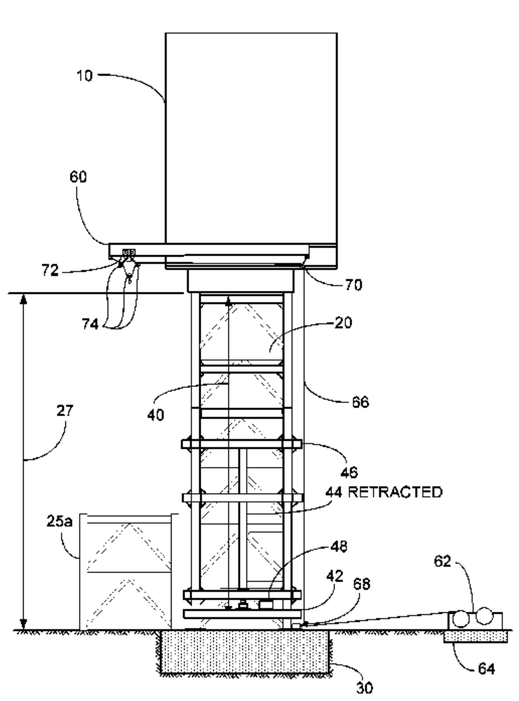
* cited by examiner

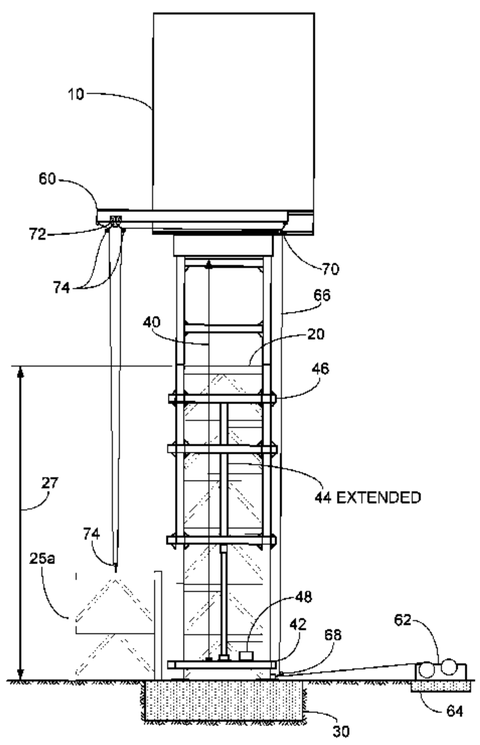
Primary Examiner — David Bryant
Assistant Examiner — Jason L Vaughan
(74) *Attorney, Agent, or Firm* — Eric Marich

(57) **ABSTRACT**

An erection method for a solar receiver and support tower provides a climbing assembly on the support tower to raise the solar receiver to its final elevation by progressively jacking and installing support tower sections to erect the tower and support the solar receiver.

6 Claims, 8 Drawing Sheets





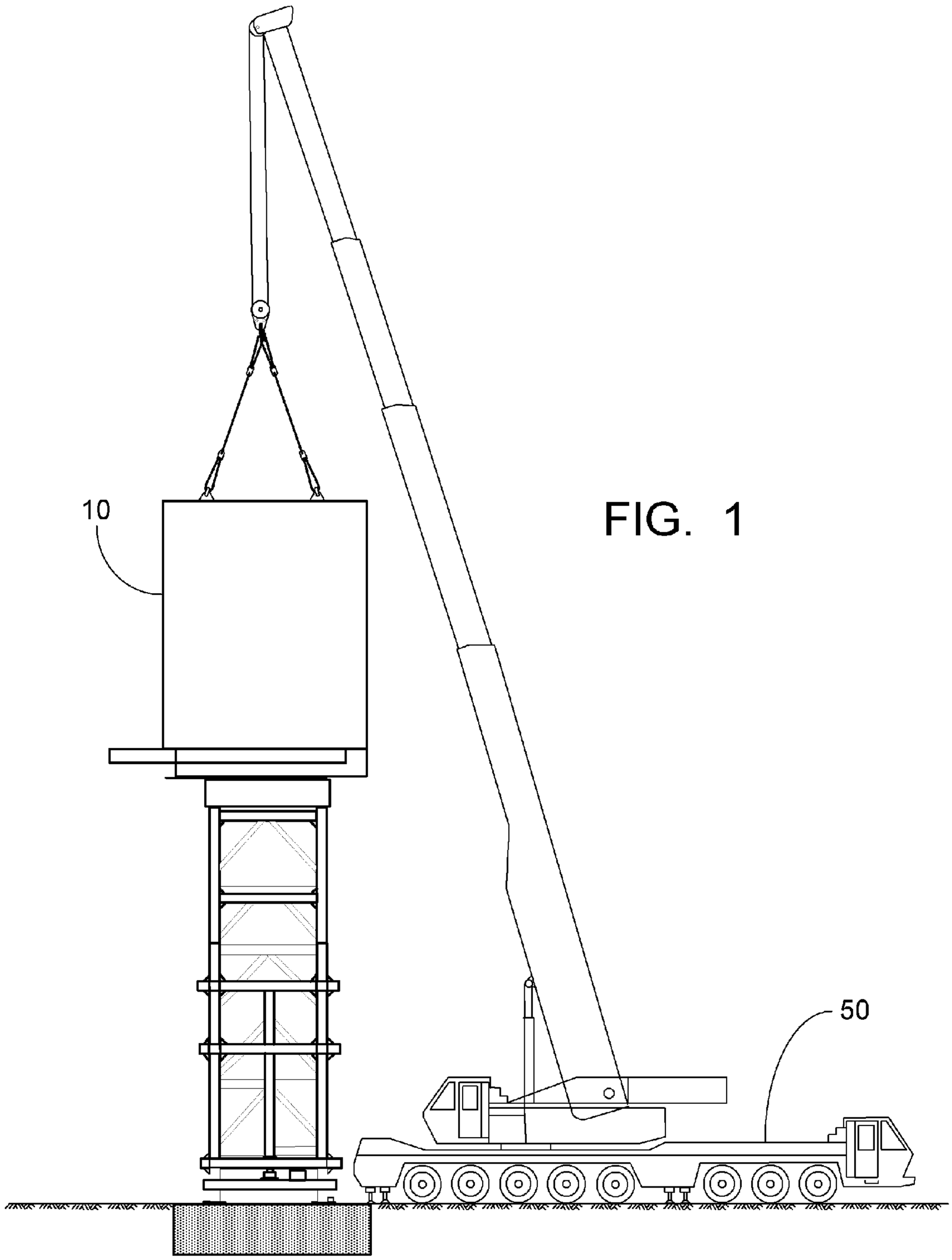


FIG. 1

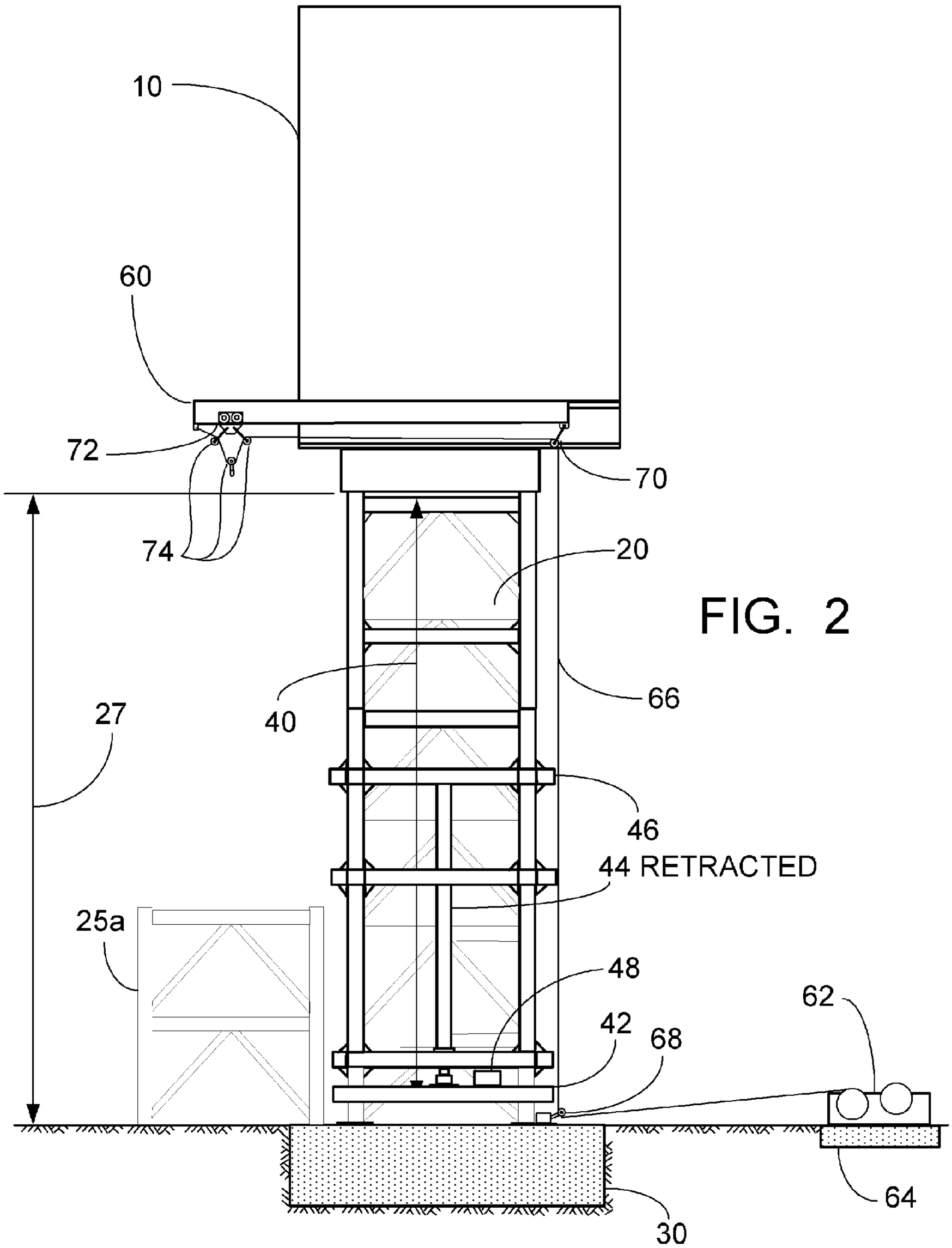


FIG. 2

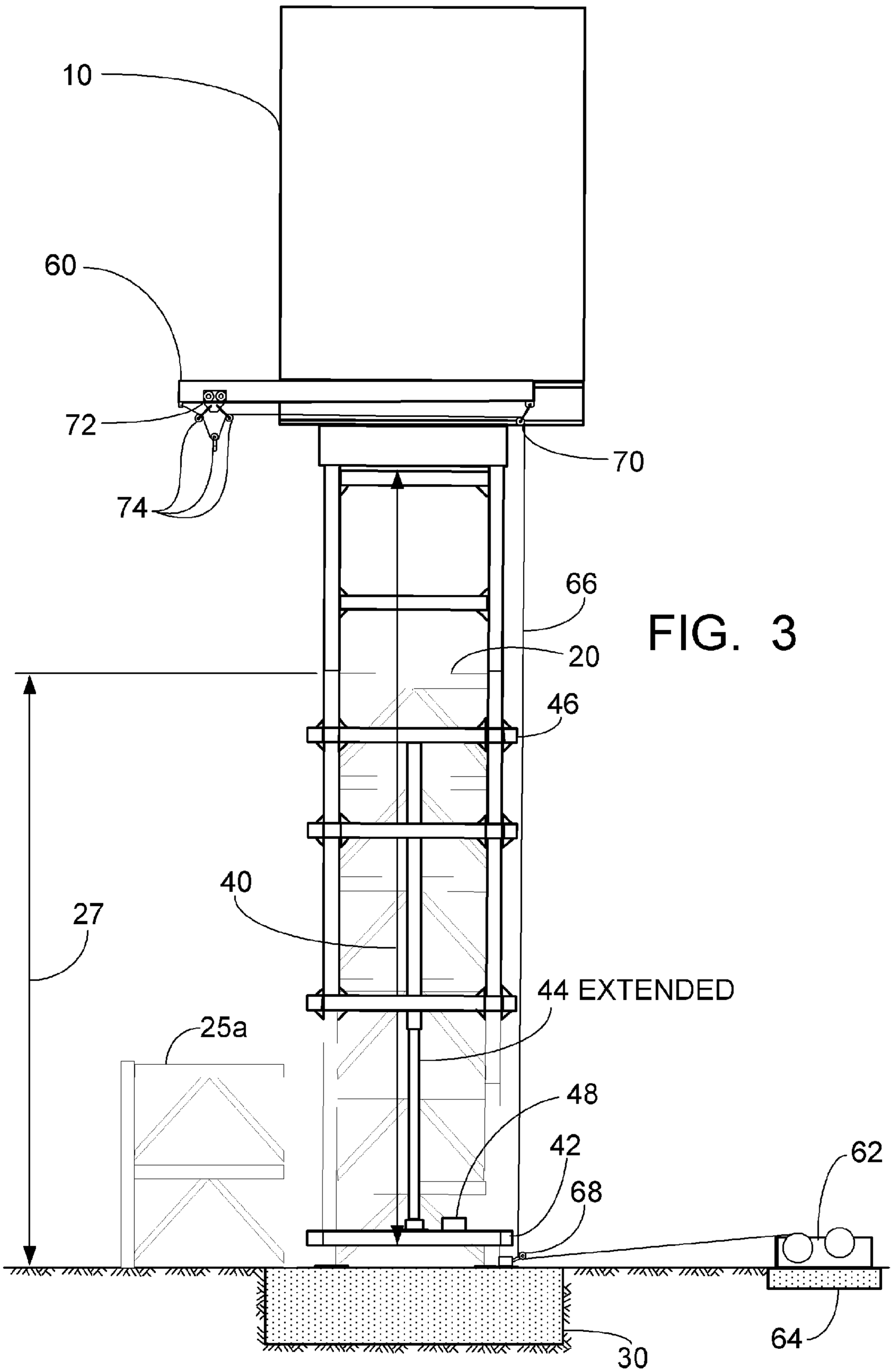


FIG. 3

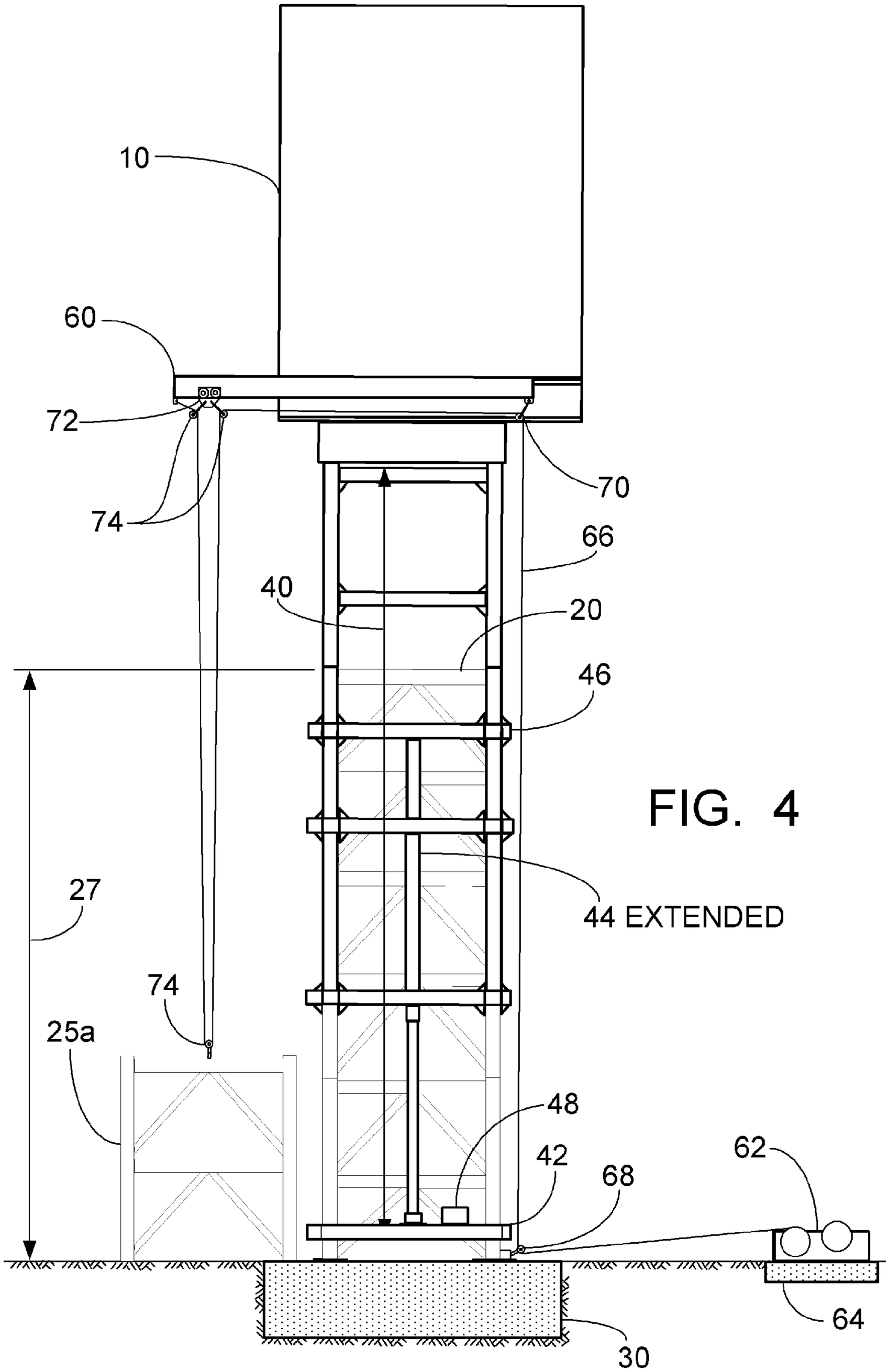


FIG. 4

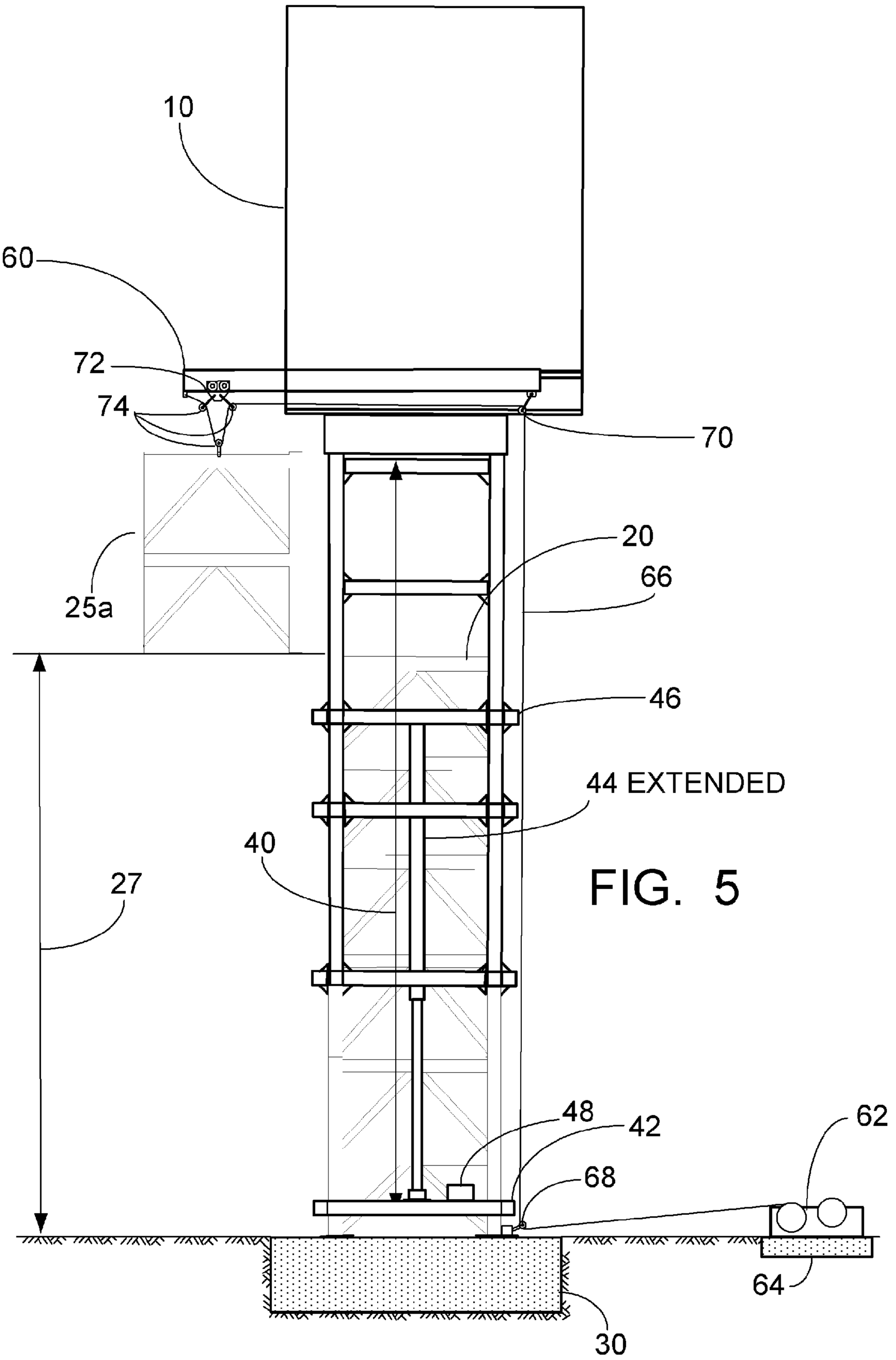


FIG. 5

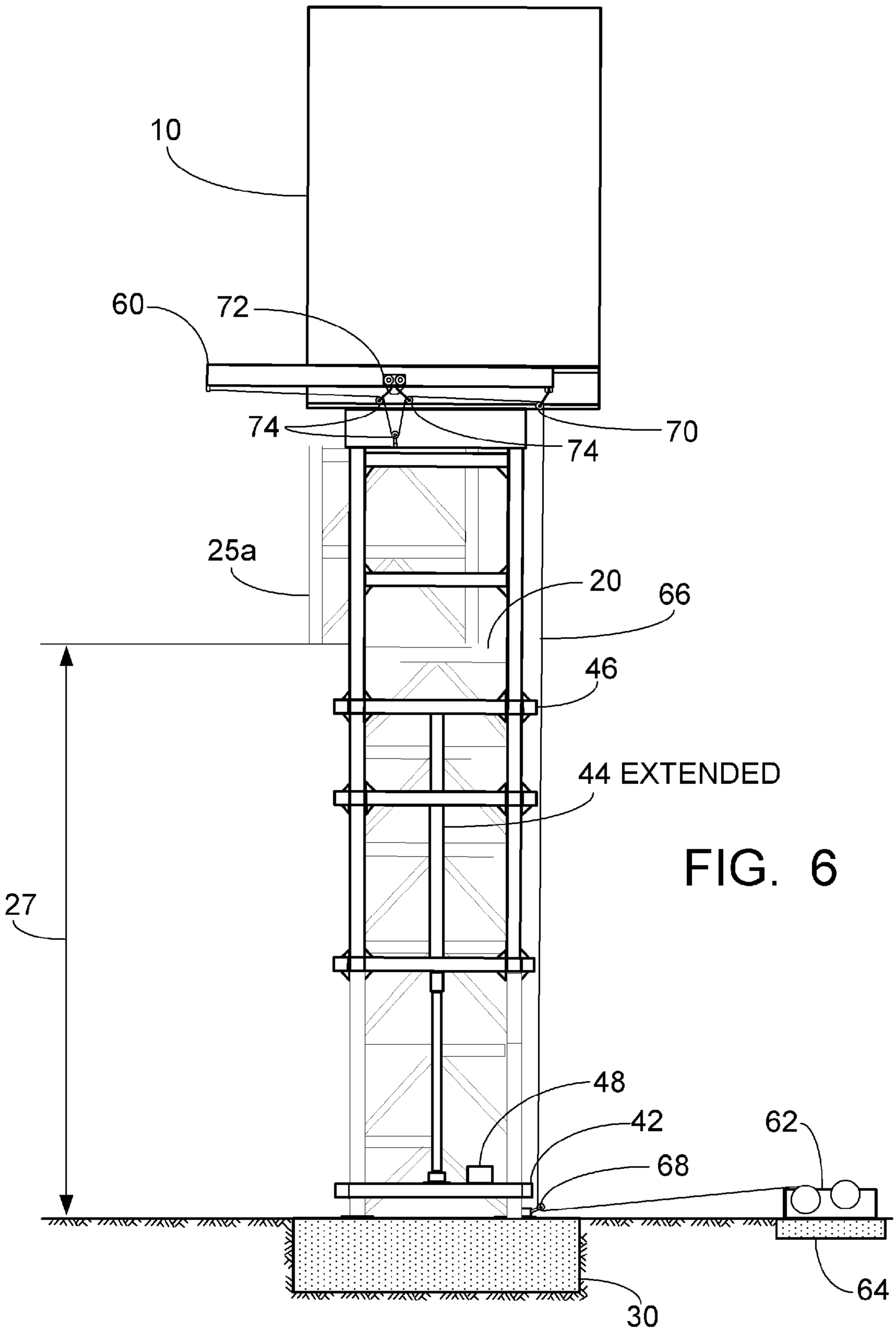


FIG. 6

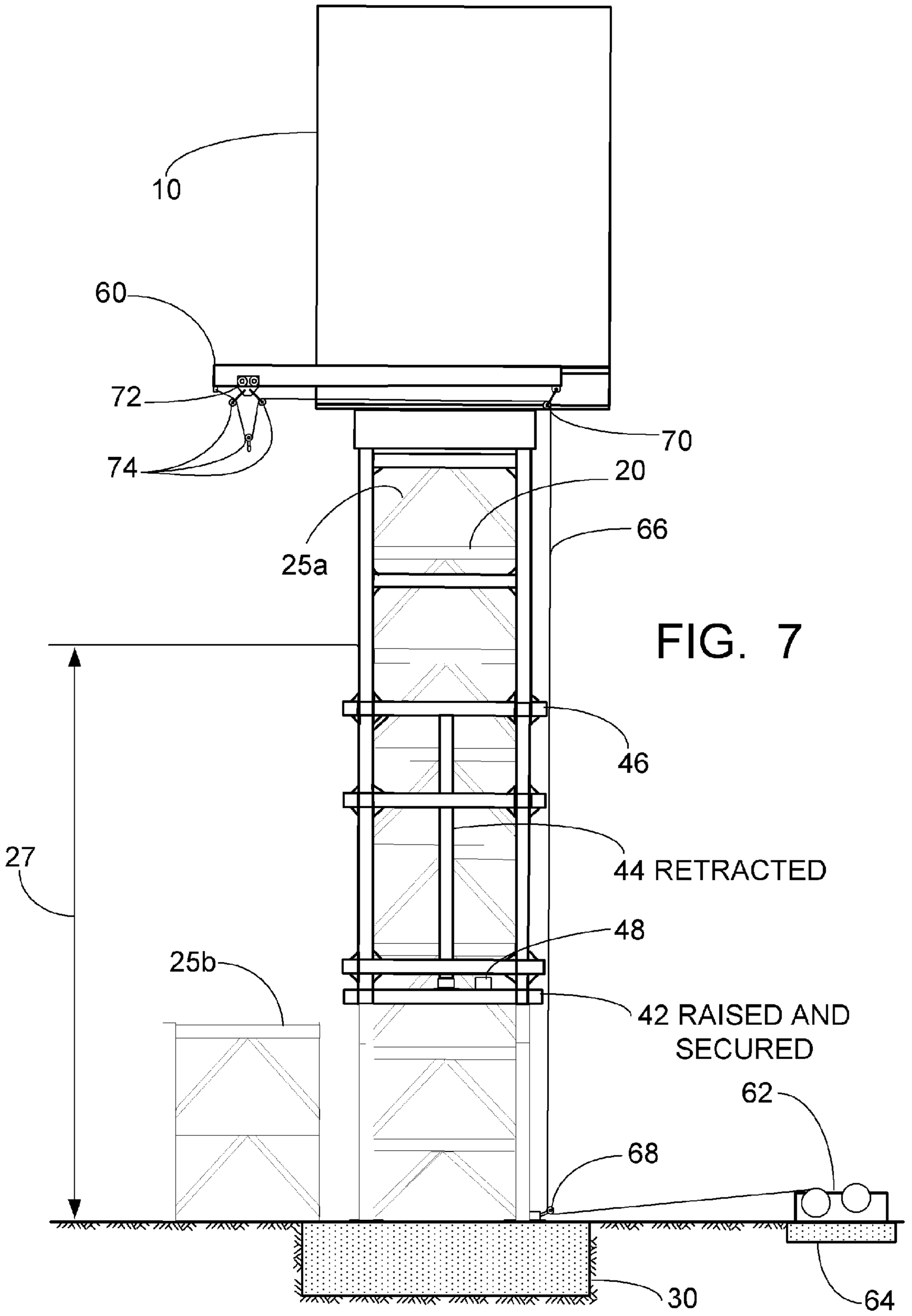
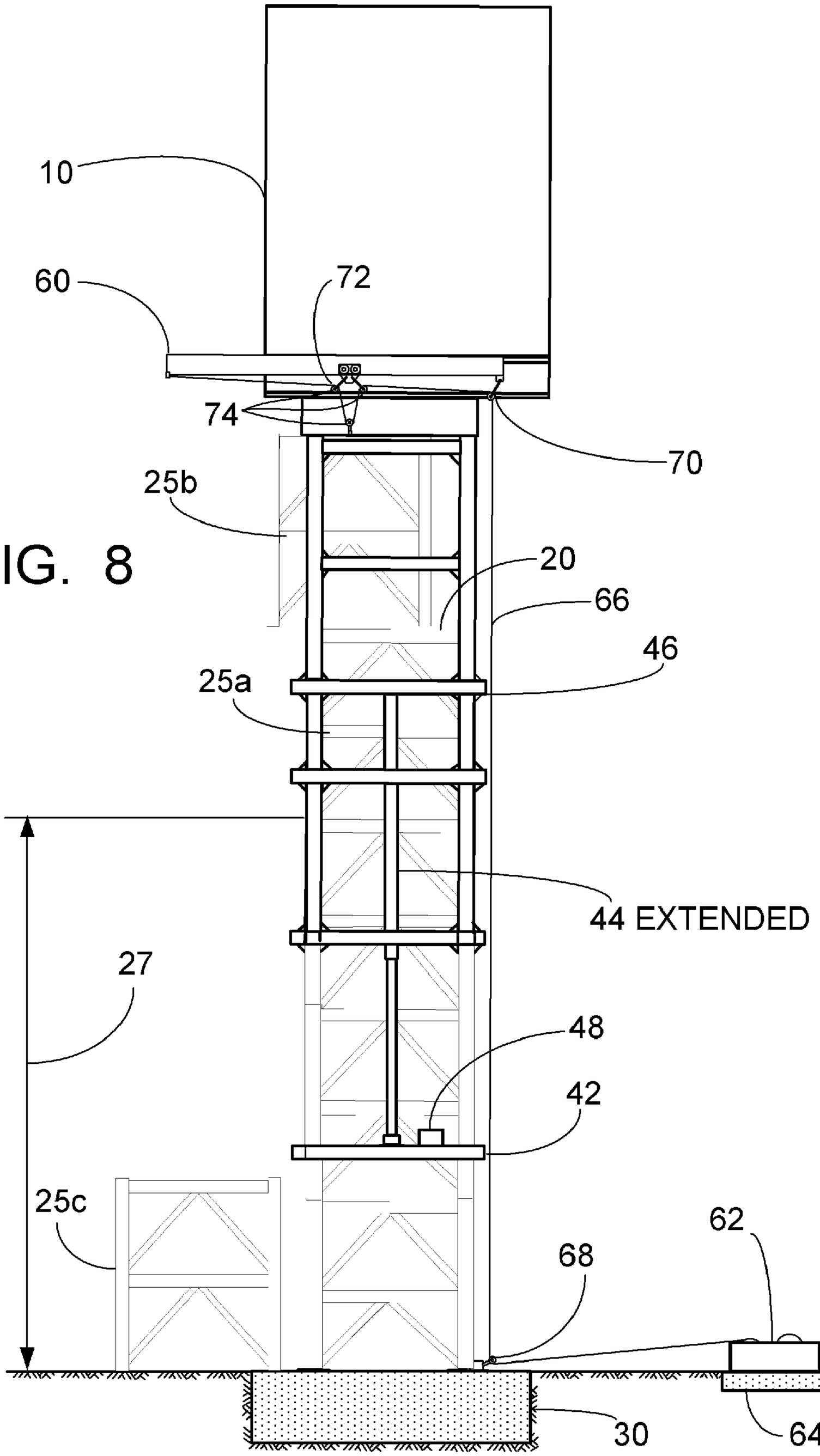

10
60
72
74
70
20
25a
66
27
46
44 RETRACTED
48
25b
42 RAISED AND SECURED
62
68
30
64

FIG. 7

FIG. 8



METHOD FOR ERECTION OF A SOLAR RECEIVER AND SUPPORT TOWER

CROSS-REFERENCE TO RELATED APPLICATION

The present invention claims priority from U.S. Provisional Application for patent Ser. No. 61/051,171, filed May 7, 2008, the text of which is hereby incorporated by reference as though fully set forth herein.

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to the field of power generation and industrial boiler design, including boilers or steam generators used in the production of steam used to generate electricity. In particular, the present invention provides a new and useful method for erection of a solar receiver and support tower in an economical, efficient manner.

A solar receiver is a primary component of a solar energy generation system whereby sunlight is used as a heat source for the production of high quality steam that is used to turn a turbine generator, and ultimately generate electricity. The receiver is permanently positioned on top of an elevated support tower that is strategically positioned in a field of heliostats, or mirrors, that collect rays of sunlight and reflect those rays back to target wall(s) in the receiver. The height of the solar receiver support tower is established by the arrangement of the heliostat field and the operation of the heliostats in that field.

Conventionally, the construction of the solar receiver and its support tower employs heavy lift crawler cranes for placement of support tower sections on the tower foundation, and for placement of the assembled solar receiver on the tower. Due to the weight of the solar receiver, and the height of the tower above grade, required heavy lift cranes are, of necessity, very high capacity. High capacity mobile lift cranes are of limited availability, are high cost, and must operate on prepared ground capable of withstanding relatively high imposed bearing pressures. Because of their overall size, even though these heavy lift cranes are classified as mobile cranes, they are not readily repositioned between solar receiver placements in a typical solar energy generation installation. Transportation between operating positions at each receiver support tower requires assembly/disassembly/re-assembly of the heavy lift crane.

SUMMARY OF THE INVENTION

The present invention eliminates the need for these heavy lift crawler cranes for erection of the solar receiver and its respective support tower.

The present invention provides an erection method for a solar receiver and support tower which employs a climbing assembly to raise the solar receiver to its final elevation by progressively jacking and installing support tower sections.

Accordingly, one aspect of the present invention is drawn to an erection method for a solar receiver and support tower comprising the steps of providing a climbing assembly on the support tower to raise the solar receiver to its final elevation by progressively jacking and installing support tower sections to erect the tower and support the solar receiver.

Another aspect of the present invention is drawn to a method for erecting a solar receiver and support tower therefor, the method comprising the steps of: (a) providing a solar receiver; (b) providing a support tower in the form of two of more support tower insert sections and wherein at least one of the support tower insert sections is designed to finally receive and support the solar receiver; (c) providing a climbing assembly, wherein the climbing assembly is designed to raise the solar receiver to a final height by progressively jacking and installing support tower insert sections between a first support tower insert section and the bottom of the solar receiver; (d) placing the solar receiver on top of the first support tower insert section; and (e) progressively jacking and installing one or more additional support tower insert sections between the first support tower insert section and the bottom of the solar receiver.

Yet another aspect of the present invention is drawn to a method for erecting a solar receiver and support tower therefor, the method comprising the steps of: (i) providing a solar receiver; (ii) providing a monorail secured adjacent the solar receiver; (iii) providing a support tower, wherein the support tower comprises two or more support tower insert sections and wherein at least one of the support tower insert sections is designed to finally receive and support the solar receiver; (iv) providing a hydraulic climbing assembly, wherein the hydraulic climbing assembly is designed to raise the solar receiver to a final height by progressively jacking and installing support tower insert sections between a first support tower insert section and the bottom of the solar receiver; (v) placing the solar receiver on top of the first support tower insert section; and (vi) progressively jacking and installing support tower insert sections between a first support tower insert section and the bottom of the solar receiver.

Still another aspect of the present invention is drawn to a method for erecting a solar receiver and support tower therefore, the method comprising the steps of: (A) providing a solar receiver; (B) providing a monorail secured adjacent the solar receiver (C) providing a support tower, wherein the support tower comprises two or more support tower insert sections and wherein at least one of the support tower insert sections is designed to finally receive and support the solar receiver; (D) providing a hydraulic climbing assembly, wherein the climbing assembly is designed to completely encompass the at least one of the support tower insert sections and wherein the hydraulic climbing assembly is designed to raise the solar receiver to a final height by progressively jacking and installing support tower insert sections between a first support tower insert section and the bottom of the solar receiver; (E) placing the solar receiver on top of the first support tower insert section; and (F) progressively jacking and installing support tower insert sections between a first support tower insert section and the bottom of the solar receiver.

In all of these aspects, the last Step in each of these methods is repeated until a desired number of support tower insert sections have been installed.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and the specific benefits attained by its uses, reference is made to the accompanying drawings and descriptive matter in which preferred embodiments of the invention are illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

In the Figures:

FIG. **1** is a schematic illustration of a first step of the erection method according to the present invention, wherein a hydraulic crane is used for initial load handling operations;

FIG. **2** is a schematic illustration of a subsequent step of the erection method according to the present invention, wherein a support tower insert section has been placed adjacent the tower;

FIG. **3** is a schematic illustration of a subsequent step of the erection method according to the present invention, after the first climbing sequence has taken place;

FIG. **4** is a schematic illustration of a subsequent step of the erection method according to the present invention, after the first climbing sequence has taken place, and wherein a support tower insert section is ready to be lifted;

FIG. **5** is a schematic illustration of a subsequent step of the erection method according to the present invention, wherein a support tower insert section has been lifted to an upper portion of the support tower;

FIG. **6** is a schematic illustration of a subsequent step of the erection method according to the present invention, wherein a support tower insert section is in the process of being inserted into an upper portion of the support tower;

FIG. **7** is a schematic illustration of a subsequent step of the erection method according to the present invention, illustrating the repositioned climbing assembly after the first climbing sequence has taken place; and

FIG. **8** is a schematic illustration of a subsequent step of the erection method according to the present invention, wherein a second support tower insert section is in the process of being inserted into an upper portion of the support tower.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings generally, wherein like reference numerals designate the same or functionally similar elements throughout the several drawings, and to FIG. **2** in particular, there is shown a schematic illustration of the equipment involved in the method for erection of a solar receiver and support tower according to the present invention.

The method involves the use of a climbing assembly **40** to raise a solar receiver **10** to its final elevation by progressively jacking and installing support tower insert sections **25**. As shown on FIG. **2**, climbing assembly **40** comprises a collar assembly **42**, hydraulic cylinders **44**, and a climber mechanism **46** which are all adapted into the design of support tower **20**. Climbing assembly **40** completely encompasses the periphery of support tower **20** framing members, such that the inside dimensions of climbing assembly **40** are approximately equal to the outside dimensions of support tower **20**. Collar assembly **42** is affixed to the framing members in place on four sides of tower **20**, and forms the base that supports two hydraulic cylinders **44** positioned on opposite sides of support tower **20**. Hydraulic cylinders **44** are connected to climber mechanism **46** on two sides. Climber mechanism **46** is a structural framework that surrounds support tower **20** on four sides so as to be guided and stabilized by support tower **20** during a climbing operation. When hydraulic cylinders **44** are extended, the hydraulic cylinder sides of climber mechanism **46** are of a height that allows for installation of a support tower insert section **25** through the sides of climber mechanism **46** perpendicular to the hydraulic cylinder sides. In the Figs., the first support tower insert section is designated **25***a*, the second **25***b*, the third **25***c*, etc. Although not illustrated in the Figs., each support tower insert section **25** is also provided with shop-fabricated stairs and landings to provide ready access over the height of the support tower **20**. The load of solar receiver **10** is assumed on the cylinder sides of climber mechanism **46**, transferred to the hydraulic cylinders **44**, and withstood by collar assembly **42** until the next support tower insert section **25** is installed. Hydraulic cylinders **44** are powered by a hydraulic control unit **48** placed on a platform in support tower **20** in close proximity to cylinders **44**.

The method of erection using climbing assembly **40** is described on FIGS. **1** through **8** and as set forth in the following paragraphs.

As shown in FIG. **1**, which is a schematic illustration of a first step of the erection method according to the present invention, hydraulic crane **50** is used for initial load handling operations at the start of construction. In comparison to the heavy lift crane required for placement of a solar receiver **10** on top of the completed support tower **20**, hydraulic crane **50** is much smaller in dimension and capacity, more available, less costly and much more practical and expedient.

As shown in FIG. **2**, which is a schematic illustration of a subsequent step of the erection method according to the present invention, a support tower insert section **25***a* has been placed adjacent the tower **20**. Following completion of a suitable tower foundation **30** and receipt of confirmation that the 28 day compressive strength of the foundation concrete has been attained, installation of the solar receiver support tower **20** begins via a method described herein. Via the use of a hydraulic crane **50**, a base tower section **27** is erected, leveled, aligned and plumbed on foundation **30**. Base tower section **27** is secured in a final position by tightening the base connection to anchor rods embedded in the concrete that forms foundation **30**. Next, climbing assembly **40** is installed on base tower section **27**.

The height of base tower section **27** is not limited to any one specific height. Rather, base tower section **27** is designed to have the height needed to receive the combined length of climber mechanism **46**, collar assembly **42** and the retracted length of hydraulic cylinders **44**.

As tower foundation **30** is being constructed and base tower section **27** is being installed, the individual shipping components of solar receiver **10** can be ground assembled into a complete unit for lifting to final position after base tower section **27** is erected. If solar receiver **10** is already a substantially complete unit as-delivered from the manufacturing facility, solar receiver **10** can be lifted into place on top of base tower section **27**, after base tower section **27** is erected.

A monorail **60** is incorporated into the support framing, secured adjacent to solar receiver **10**, advantageously at the base of solar receiver **10**, and cantilevers a distance approximately half the plan dimension of support tower **20**. This arrangement permits support tower insert sections **25***a*, **25***b*, **25***c*, etc. to be raised to elevation immediately outboard of tower **20** in place. In one embodiment, monorail **60** is sized to provide lifting capacity equal to the rigging weight of support tower insert sections **25** above base tower section **27**. The hoisting mechanism provided for monorail **60** is powered by a base mounted two drum waterfall hoist **62** secured on a reinforced concrete foundation slab **64** near the base of solar receiver support tower **20**. Load lines **66** extend over the fair lead distance from the hoist to lead sheaves **68** mounted on the base of tower **20**, are routed up the outside of tower **20** to sheaves **70** attached to the end of monorail **60**, and finally routed along monorail **60** to fit to trolleys **72** and load blocks **74** operating on monorail **60**. These load lines **66** are used to raise and/or lower the load and to position the trolleys along the length of monorail **60**.

Refer now to FIGS. **3**, **4**, **5**, **6** and **7**. Once installation of base tower section **27** and climbing assembly **40** is completed, and solar receiver **10** with monorail **60** is in place, the first climbing sequence begins. With collar assembly **42** secured to base tower section **27**, and climber mechanism **46**

secured to solar receiver **10**, hydraulic cylinders **44** extend to the length required to permit installation of the next support tower insert section **25**. FIG. **3**. Support tower insert section **25***a* is positioned on the ground adjacent to base tower section **27** in place, and beneath the hoisting hook on monorail **60**. FIG. **4**. The hoisting hook is attached to support tower insert section **25***a*, and section **25***a* is raised to an elevation just above the portion of base tower section **27** that is in place. FIG. **5**. Once at the desired elevation, support tower insert section **25***a* is trolleyed into position over base tower section **27** in place. FIG. **6**. Next, mating surfaces on base tower section **27** and support tower insert section **25***a* are brought into contact and securely connected. Collar assembly **42** is disconnected from the tower framing, and is raised to its next upper point of securement as hydraulic cylinders **44** retract. FIG. **7**. At the retracted position of hydraulic cylinders **44**, collar assembly **42** is reattached to the support tower framing, and the first climbing sequence is completed.

The second climbing sequence duplicates the first, as do all remaining sequences until all support tower insert sections **25***b*, **25***c*, etc. are in place and solar receiver **10** is at its final elevation. FIG. **8**.

Upon attachment of solar receiver **10** to the topmost support tower insert section **25** and completion of support tower **20** erection, climbing assembly **40** is brought to the ground by reversing the sequence of climbing operations. Climber mechanism **46** is secured to support tower **20** and detached from solar receiver **10**. Collar assembly **42** is detached from support tower **20**'s framing and is suspended from hydraulic cylinders **44**. Hydraulic cylinders **44** extend and lower collar assembly **42** to its next lower point of securement. Collar assembly **42** is reattached to support tower **20**'s framing and climber mechanism **46** is detached from support tower **20**. Hydraulic cylinders **44** retract and lower climber mechanism **46** to its next lower point of securement to the support tower framing. Climber mechanism **46** is resecured, collar assembly **42** is detached, and the next lowering sequence proceeds in similar manner. Lowering sequences continue until climbing assembly **40** reaches its lowest position on support tower **20**. At this lowest position, climbing assembly **40** is disassembled via use of hydraulic crane **50**.

In conjunction with the assembly and/or erection of solar receiver **10** and support tower **20**, feed water and high pressure steam piping (not shown) are appropriately routed up support tower **20** (e.g., on a side or sides of support tower **20**). In one embodiment, the piping is constructed via the use of monorail **60** and the hoisting mechanism.

In one embodiment, monorail **60** can be left in place. Alternatively, monorail **60** can be removed. The hoisting mechanism, including hoist **62** at grade, lead sheaves **68**, **70**, trolleys **72** and load blocks **74**, can or cannot be left in place per the discretion of the owner.

The advantages of the invention are many, and include:

1. The invention provides a safe, economical, efficient and practical means of erection of solar receivers and support towers.
2. The invention provides a means of erection of solar receivers and support towers that is independent of specific site constraints and restrictions.
3. The invention eliminates the need for high capacity, high cost, and limited availability heavy lift cranes for the erection of solar receivers and support towers.
4. The invention eliminates the need for project ground improvement for the placement of heavy lift cranes for the erection of solar receivers and support towers.
5. The invention uses the existing permanent construction of the solar receiver and support tower as the erection means for the solar receiver and support tower, and minimizes the need for any temporary installations.
6. The invention provides a means of solar receiver and support tower erection via the climbing assembly that is readily truck shippable to any site, with a minimum number of shipments.
7. The invention provides a means of completing solar receiver and support tower erection whereby critical rigging, handling and welding operations are performed at or near ground elevation.
8. The invention provides an integral means for installation of critical feed water and high pressure steam piping.
9. The invention provides a means of readily lowering and/or raising the solar receiver for any possible future maintenance operations.
10. With some adaptation of the climbing assembly to suit the cross sectional dimensions of the support tower, the invention provides a means of erection of solar receivers and support towers of unlimited height.
11. The invention offers a "green benefit". In order to get permits for construction in the state of California, for example, a heavy equipment list must be submitted for evaluation with regard to pollutant emissions. Eliminating the need for heavy lift crawler cranes reduces construction pollutant emissions and enhances the prospect for a favorable project evaluation with respect to this aspect.

It will thus be readily appreciated that the present invention overcomes the difficulties and reduces the cost and time required to erect a solar receiver and its support tower with conventional erection techniques which require expensive, heavy lift crawler cranes for placement of support tower assemblies on the tower foundation, and for placement of the assembled solar receiver on the tower.

While the principles of the present invention may be particularly applicable to new solar receiver installations, it will be appreciated that the present invention may be applied to construction involving the replacement, repair or modification of existing solar receivers. In some embodiments of the invention, certain features of the invention may sometimes be used to advantage without a corresponding use of the other features. Accordingly, while specific embodiments of the present invention have been shown and described in detail to illustrate the application and principles of the invention, it will be understood that it is not intended that the present invention be limited thereto and that the invention may be embodied otherwise without departing from such principles. All such changes and embodiments properly fall within the scope of the following claims.

We claim:

1. A method for erecting a solar receiver and support tower therefore, the method comprising the steps of:

(A) providing a solar receiver;

(B) providing a support tower;

(C) surrounding the support tower with a hydraulic climbing assembly, wherein the climbing assembly comprises:

(i) a collar assembly;

(ii) a climber mechanism located above the collar assembly; and

(iii) a plurality of hydraulic cylinders connecting the collar assembly to the climber mechanism;

(D) securing the collar assembly to the support tower;

(E) securing the climber mechanism to the solar receiver;

(F) extending the hydraulic cylinders to raise the climber mechanism;

(G) inserting a support tower insert section between the support tower and the bottom of the solar receiver to increase the height of the support tower;

(H) placing the solar receiver on top of the support tower

(I) disconnecting the collar assembly from the support tower;

(J) retracting the hydraulic cylinders to raise the collar assembly;

(K) securing the collar assembly to a next securement point on the support tower.

2. The method of claim **1**, wherein the solar receiver is completely assembled prior to being placed on top of the climber mechanism.

3. The method of claim **1**, wherein the solar receiver is assembled piece-meal on top of the climber mechanism.

4. The method of claim **1**, wherein the climber mechanism comprises a lattice structure that is designed to permit the ingress of at least one support tower insert section into the interior thereof.

5. The method of claim **1**, further comprising repeating Steps (E) through (K) until a desired number of support tower insert sections have been installed.

6. The method of claim **1**, wherein a monorail is secured adjacent the solar receiver, the monorail being designed to insert the support tower insert section between the support tower and the bottom of the solar receiver.

* * * * *